

EVALUATION OF CLEARING PROCEDURES FOLLOWING  
METHYL BROMIDE AND SULFURYL FLUORIDE (VIKANE)  
STRUCTURAL PEST CONTROL FUMIGATIONS

by

Dennis B. Gibbons, Senior Industrial Hygienist  
Linda O'Connell, Associate Environmental Hazards Scientist  
Carolyn Rech, Environmental Hazards Scientist  
John Costello, Environmental Hazards Scientist

HS-1538 September 12, 1989

California Department of Food and Agriculture  
Division of Pest Management, Environmental  
Protection and Worker Safety  
Worker Health and Safety Branch  
1220 N Street, P.O. Box 942871  
Sacramento, California 94271-0001

SUMMARY

Worker exposure to the fumigants methyl bromide and sulfuryl fluoride was measured during the clearing (aeration) procedures following the fumigation of nine private residences in southern California in October 1987. This pilot study was conducted in cooperation with industry representatives and designed to evaluate existing work practices and to develop/suggest modifications to these procedures that might offer greater protection to the worker, should particular work practices be found to pose unacceptable exposure hazards. Measurements of worker exposure were gathered during the clearing procedures of six residences treated with sulfuryl fluoride and three treated with methyl bromide. Results suggest that improved clearing methods are needed to provide increased worker protection during these procedures. One method of reducing worker exposure that appears to be practical involves reducing the volume of air between the tarpaulin and the structure and reducing the concentration of fumigant remaining within the structure. Using existing industry equipment, the terminal concentration can be lowered by mechanical exhaust ventilation of the tarpaulined structure prior to the start of the clearing procedures. The study also showed the bagging of foodstuffs does not prevent contact with these fumigants.

## INTRODUCTION

A three-day study was conducted in cooperation with the Pest Control Operators of California (PCOC) to evaluate clearing procedures used in the structural fumigation of residences. This study was conducted from October 13 - 15, 1987. A total of nine clearing operations were monitored. Six of the structures had been treated with sulfuryl fluoride and three with methyl bromide.

The primary purpose of this study was to evaluate the current work practices by characterizing typical worker exposure during each step of the normal clearing procedures and also to develop/suggest mitigating measures that could be adopted to lessen exposure. In addition, a measurement of residual fumigant in bagged foodstuffs was to be obtained at any site where items of food were found that had been subject to the fumigation. This was conducted to determine if the fumigants penetrate typical materials used for bagging as was indicated by an earlier Worker Health and Safety Branch study.<sup>1</sup>

Specific work activities identified by the industry representatives for clearing a residential structure include: 1) Breaking and removal of the ground seal, 2) Removing the clips holding the tarpaulin together, 3) Opening seams, 4) Lifting tarpaulins from behind shrubbery, 5) Peeling back the tarpaulins, and 6) Folding the tarpaulins. These six tasks all present potential for exposure to these fumigants in varying degrees. A description of each of these tasks follows:

- Ground Seal Removal (GS) This initial step involves removing the "sand" or "water snakes." These snakes (long canvas tubes filled with sand or plastic tubes that are filled with water) are used to hold the bottom of the tarpaulin to the surface of the ground and form a seal during the fumigation. During this step the workers remove the snakes and return them to their truck. This step was performed in about five minutes by most three-person crews.

- Clip Removal (CR) This step involves removing the large clips that hold the edges of adjoining tarpaulins together. At times, as the clips are removed, the tarpaulins will begin to pull away from each other. This step can pose the potential for considerable exposure. When removing clips, workers are in close proximity to the air space confined directly behind the tarpaulin. This air space may contain various volumes of remaining fumigant at levels up of several thousand ppm concentration. If the seams come apart during this step, there is the potential for significant exposure. Clips are collected and then returned to the fumigation company truck.

- Seam Opening (SO) During this step the tarpaulins are pulled apart to open seams and allow the escape of remaining fumigant. Workers typically pull the seams apart by pulling on the tarpaulin from a position away from the seam. This practice can help to minimize exposure. Although identified as a separate step, at most sites this step was combined with the clip removal step by the clearing crews.

- Shrubby (S) During this step, the tarpaulins are removed from around or behind shrubbery that has been covered or has been surrounded by tarpaulins during the fumigation. In most cases, this step was combined

with the peeling of tarpaulins step.

- Peeling Tarpaulins (PT) During this step, the tarpaulins are pulled off of the structure and dragged to a position on the ground to allow folding.

- Folding of Tarpaulins (FT) For this final step, the tarpaulins are folded on the ground and returned to the company truck.

The results of this study will be used to direct further research into improved methods of providing protection to the workers involved in structural fumigation.

#### METHODS AND MATERIALS

The various identified work tasks were evaluated for worker exposure by collecting and analyzing air samples during the time the worker was involved in each task. To accomplish this, air samples were collected by drawing air from a tube positioned in the breathing zone of the worker, pumping this air through a personal air sampling pump and then into a collection bag. Personal air sampling pumps (MSA C-210) were attached to the belts of the workers and were used in conjunction with 3-liter Tedlar air sampling bags. The bags were attached to the back of the shirt of each worker with safety pins. The inlet tube was positioned on the collar of the worker. Because these fumigants are truly gases, orientation of the sampling inlet was not critical as long as it remained in the breathing zone. As each task was completed, the worker was instructed to stop at the sampling station we established, the bag removed and the worker provided with a new bag for the next identified work task. According to our protocol, six air bags were to be collected from each worker corresponding to the six identified specific tasks. At some sites, however, more than one task was completed before the sampling bag was changed. Some combination of tasks occurred at most of the sites. For these sites, the exposure measurements cover the time period necessary to perform two or more tasks. Air pumps were calibrated to deliver somewhat less than the capacity of the bag during the anticipated sampling time period of each phase and in most cases could accommodate the occasional combined period sample. Typically, there are three persons in a fumigation crew. Occasionally a crew would have four members with the fourth member being a supervisor. During this work, three workers were monitored at each site.

Analysis of the concentration of fumigant within each sampling bag differed with the type of fumigant. For the structures treated with sulfuryl fluoride, as the bags were collected at the sampling station, they were immediately analyzed to determine the concentration of this fumigant with our Interscan Vikane Analyzer. In addition, a similar instrument was used by personnel from the Tri-Cal company to obtain duplicate measurements. Properly calibrated, this instrument will measure sulfuryl fluoride to 50 ppm with an accuracy of +/- five percent of full scale. Values reported are the average of the field observed readings of the CDFA and industry instrument. The detection limit of this instrument was considered to be when there was no meter response and some response is reported as less than one ppm. Calibration was performed prior to each site clearing operation by use of a sulfuryl fluoride gas standard (Scott-Marin, Inc., Riverside, CA) provided by the Tri-Cal company.

If the structure had been fumigated with methyl bromide, we had planned to use a portable gas chromatograph. However, we were unable to use this instrument due to technical problems. Fortunately, the Tri-Cal company had installed a laboratory-type gas chromatograph at their facility nearby and measurements of the methyl bromide concentrations reported are as a result of their analyses. For these methyl bromide analyses, two 15 mL gas syringe samples were withdrawn from each air sampling bag and transported to the nearby Soil Chemicals Corporation office where the analysis was performed by laboratory personnel from the Tri-Cal company. The minimum detectable level for their instrument was 0.5 ppm with an accuracy of +/- 0.25 ppm.

A measurement of the concentration of the fumigant remaining inside the tarpaulined structure was obtained at each site. Just prior to the start of any clearing activity at each site, an air line was placed in the structure by a member of the industry personnel. Air from inside the structure was then withdrawn and passed through a Fumiscope. A Fumiscope is a thermoconductivity type instrument designed to measure the concentration within a fumigation site. This instrument operates in the ounces/ft<sup>3</sup> (several hundred to thousands ppm) range, will measure both sulfuryl fluoride and methyl bromide and is used by the structural pest control industry to evaluate efficacy of treatment. We used this measurement to determine the terminal concentration of fumigant to relate to the potential for worker exposure during subsequent clearing operations.

A measurement of residual fumigant in bagged foodstuffs was obtained at any site where items of food were found that had been subject to the fumigation. This was conducted to determine if the fumigant is penetrating typical materials used for bagging and, if so, what levels of fumigant might exist in the bags.

At some sites, a measurement of the residual fumigant was obtained at the time of entry to open windows and doors. This measurement was obtained using the same sampling bag technique used for the clearing procedures. However, the air concentration value obtained does not represent worker exposure since this initial reentry was performed by a worker wearing appropriate respiratory protective equipment (self-contained breathing apparatus (SCBA)).

This study was initially planned for two days. On the first day of this study, monitoring was conducted of the workers involved in the clearing procedures of four residences that had been fumigated with sulfuryl fluoride. On the second day, clearing procedures were monitored for three residences that had been fumigated with methyl bromide. Two additional residences treated with sulfuryl fluoride were monitored on a third day.

For this evaluation of clearing procedures, exposure measurements were compared to label-mandated exposure limits of 5 ppm for both methyl bromide and sulfuryl fluoride. Product labels for these two fumigants use 5 ppm as an airborne level above which respiratory protection is necessary. Exposure measurements were also compared to recognized occupational exposure values such as the Cal/OSHA Permissible Exposure Limits (PELs)<sup>2</sup>, Fed/OSHA PELs<sup>3</sup> or ACGIH TLV<sup>Rs</sup><sup>4</sup>. These occupational exposure limits or guidelines are measured as eight-hour time-weighted averages. The ACGIH also has a Short Term Exposure Limit (STEL) of 10 ppm for sulfuryl fluoride. The STEL is also a time-weighted average level thought not to present adverse health

effects for limited periods of time. The STEL is defined as a 15-minute time-weighted average exposure not to be exceeded at any time during a workday. The values are listed below:

TABLE I

Comparison of Various Exposure Standards Applicable in California

<u>Fumigant</u>	<u>Label Value</u>	<u>CAL/OSHA PEL</u>	<u>FED/OSHA PEL</u>	<u>ACGIH TLV<sup>R</sup></u>
Methyl Bromide	5 ppm max	15 ppm TWA 25 ppm Ex 50 ppm C	20 ppm TWA/C	5 ppm TWA
Sulfuryl Fluoride	5 ppm max	5 ppm TWA	5 ppm TWA	5 ppm TWA 10 ppm STEL

Notes for Table I:

Label Value - Fumigant product label requirement for respiratory protection if airborne workplace concentrations exceed specific value.

TWA - Time Weighted Average - usually averaged over an eight hour period.

PEL - Permissible Exposure Limit (OSHA requirement). The maximum permitted 8-hour time weighted average concentration of an air contaminant to which an employee can be exposed.

Ex - Excursion - Maximum concentration to which an employee can be exposed without regard to duration provided the 8-hr TWA is not exceeded (OSHA requirement).

C - Ceiling - Airborne exposure concentration not to be exceeded (OSHA and ACGIH).

TLV<sup>R</sup> - Threshold Limit Value - Trademark of the American Conference of Governmental Industrial Hygienists (ACGIH). Eight-hour TWA airborne concentration thought to not result in adverse health effects for normal working lifetime.

STEL - Short Term Exposure Limit - ACGIH terminology - airborne concentration limit for short time periods to provide protection from certain acute health effects.

RESULTS

Details of the conditions at each fumigation worksite, the worker exposure values measured for each step of the clearing procedure and any miscellaneous measurements are included on pages 11 to 19.

## DISCUSSION

The following discussion is organized by day of the study because of the improvements to the clearing procedures that were developed as the study progressed.

### Clearing of Sulfuryl Fluoride-Treated Structures.

For the sulfuryl fluoride-treated structures monitored on the first day, worker exposure measured during ground seal removal ranged from below one ppm for a four minute period (worker "C", site 2) to 19 ppm for a 16 minute period (worker "B", site 3). Clip removal was usually combined with the seam opening step. For this part of the clearing procedures, worker exposure ranged from one ppm for a 5 minute period (site 1, worker "C") to greater than 50 ppm for a five minute period (site 2, worker "A"). The removal of the tarpaulins from around the shrubbery and further "peeling" of the tarpaulins was also usually combined at each site. For this part of the clearing procedures, worker exposure ranged from one ppm for ten minute periods (site 4, workers "A" and "B") to 47 ppm for a five minute period (site 2, worker "A"). The last step in the clearing procedure was the folding of the tarpaulins. For this step, worker exposure ranged from none detected (ND) for up to 17 minutes for two workers (site 3, worker "A" and "B") to just above 2 ppm for 20 minutes (site 4, worker "B").

Several observations were made before the end of the first day of this study. First, the clip removal/seam opening steps were the sources of the greatest exposure followed by the seam opening/peel tarp step. Second, the structures with the highest concentration of fumigant remaining prior to the start of the clearing procedures appeared to be associated with the highest exposure potential for the workers.

### Comparison With Standards.

Also, with regard to the levels measured and relation to label required exposure limits or other exposure limits, such as Cal/OSHA Permissible Exposure Limits (PELs), Fed/OSHA PELs or ACGIH TLV<sup>Rs</sup>, the values we measured represent possibly the very worst-case, peak-exposure type measurement values. For example, for the highest individual values obtained (site 2, worker "A"), if a single bag sample had been obtained, the time-weighted average (TWA) value for only the actual time involved in this step would have been near 19 ppm for the 27 minute total work time (1200 to 1227) at this site, as calculated below.

$$\begin{aligned} \text{TWA} &= \frac{(7.5 \text{ ppm} \times 4 \text{ min}) + (50 \text{ ppm} \times 5 \text{ min}) + (47 \text{ ppm} \times 5 \text{ min}) + (2 \text{ ppm} \times 2 \text{ min})}{27 \text{ min}} \\ &= 19 \text{ ppm average concentration for 27 minutes} \end{aligned}$$

Although above the 5 ppm label-required exposure value, this short duration exposure value would be reduced further if averaged over a longer interval as done for OSHA (PELs) or the exposure limit recommendations of the ACGIH. However, these values do illustrate the short term potential for significant exposure that can occur during these activities. These values also point to the need for better control over the short-term exposure conditions present during clearing procedures.

Performing the same type of calculations for all other workers monitored on the first day, shows that two others (site 3, workers "A" and "B") had exposures above 5 ppm as a time-weighted average for the actual total work time at the site. All others calculate far below 5 ppm.

Table II presents a summary of the data from the sites fumigated with sulfuryl fluoride. Exposure data listed under the appropriate task is the highest of the measured values for the workers performing those tasks at each site. The highest values are listed as a first attempt to compare exposure potential between the various worksites by looking at the worst case exposure at each site. Data are presented two ways. First, by order of study and second by terminal concentration of fumigant. The terminal concentration is what was measured inside the structure prior to the start of the clearing procedures.

#### Clearing of Methyl Bromide-Treated Structures.

On the second day, three structures that had been fumigated with methyl bromide were monitored during the clearing procedures. Monitoring was conducted in the same manner as the sulfuryl fluoride-treated structures, but actual analysis was performed after taking two 15 milliliter (mL) syringe samples of each sampling bag. These syringe samples were taken directly to the nearby Soil Chemicals Corporation office where they were analyzed by personnel from the Tri-Cal company by gas chromatography.

For the methyl bromide treated structures, worker exposure measured during ground seal removal ranged from below the detection limit for a five minute period (site 5, worker "C") to 2.14 ppm for a five minute period (site 5, worker "A"). Clip removal was usually combined with the seam opening step. For this part of the clearing procedures, worker exposure ranged from 0.54 ppm for an 18 minute period (site 6, worker "A") to 6.42 ppm for a two minute period (site 5, worker "C"). The removal of the tarpaulins from around the shrubbery and further "peeling" of the tarpaulins was only performed as a separate step at site five. For this fumigation site, exposure ranged from 2.14 ppm for five minutes (worker "C") to 6.42 ppm (worker "A") for five minutes. Worker exposure during the last step in the clearing procedure (folding of the tarpaulins), ranged from below the detection limit (site 5, worker "A") for an 11 minute period to 1.44 ppm (site 6, worker "B") for a 14 minute period.

The clearing procedure at site 7 was unique. The ground seal removal, clip removal and seam opening steps were combined. Worker exposure ranged from 3.4 ppm for a 15 minute period (worker "B") to 9.6 ppm for 18 minutes (worker "A"). The structure at this site was situated on a small narrow lot with similar two-story structures at each side. Access to the sides of this structure was limited with narrow walkways along each side, a fence and then another narrow walkway before the wall of the neighboring structures. This narrow two-story tall passageway seemed to pose additional difficulties to the clearing crew. In addition, exposure potential appeared to be greater at this structure because of the possibility of trapping the escaping fumigant longer and thus reducing the rate of dissipation by the confining nature of the nearby structures. The exposure values obtained for the workers at this site appear to show this to be the case. This observation is especially noteworthy in light of the relatively low concentration of methyl bromide remaining inside this structure prior to the beginning of the

clearing procedures. Very little fumigant remained (~ 85 ppm), yet worker exposure was considerably greater than the other sites treated with methyl bromide where the remaining fumigant was of much greater concentration. At these other sites, the escaping fumigant was not further confined and the aeration not hindered by the close proximity of neighboring structures.

Table III presents a summary of the data from the sites fumigated with methyl bromide. Again, exposure data listed under the appropriate task is the highest of the measured values for the workers performing those tasks at each site. The highest values are listed as a first attempt to compare exposure potential between the various worksites by looking at the worst case exposure at each site. Data are presented by order of study. For these residences, the order of study is the same as listing by ending concentration of fumigant. The ending concentration is what was measured inside the structure prior to the start of the clearing procedures.

By the end of the second day of monitoring, industry, county and state personnel present agreed that worker exposure during several steps was unacceptable. We also observed that the structures with higher terminal concentration of the fumigant appeared to result in higher exposure to the clearing crew (See above two tables). Also, associated with the terminal concentration inside the structure, the volume and concentration of fumigant between the structure and the tarpaulin was thought to be a source of exposure to the clearing crew. With this in mind, we planned a third day of monitoring to experiment with methods to lower the remaining fumigant concentration prior to the start of the clearing operation. By maintaining a slight negative pressure inside the tarpaulined structure with an exhaust fan, the tarpaulin would be pulled against the outside walls. This would significantly reduce or eliminate the air parcel between the inside of the tarpaulin and the outside wall of the tarpaulined structure. The concentration of fumigant within this air parcel is probably similar to the terminal concentration within the structure and is the primary source of fumigant the clearing crew employee may encounter when breaking most tarpaulin seals. Eliminating this air parcel should reduce exposure to crew members during ground seal, clip removal and seam opening.

#### Additional Testing to Evaluate Improved Methods.

Two sulfuryl fluoride treated structures were selected for the third day of testing. At the first house monitored on the third day (site 8), the initial method involved lifting the tarpaulin, positioning a fan exhausting outwardly and sealing the edge of tarpaulin to the fan with clips. This step was accomplished by an industry person wearing SCBA. These fans are used by the industry for other aeration and air circulation purposes and are readily available. The fan was installed at the front of the house. The air moving capacity of this type of fan is approximately 4000 ft<sup>3</sup> of air per minute. This fan was operated for approximately half an hour starting near the same time as the start of the ground seal removal. After a short time the tarpaulin was pulled in and held against the outside wall surface as the air was exhausted from the tarpaulined covered structure. A seam was opened on the opposite side of the structure to provide a fresh air inlet source. Although the terminal concentration was probably reduced, worker monitoring values for the ground seal removal were not substantially reduced. It appeared the position of the fan may have directed exhaust too close to the position of the fumigator's truck. As the workers dragged the sand snakes



to the truck, they may have encountered air being exhausted from the structure. However, the exposure values for the remaining steps of the clearing procedures for this structure appeared to be reduced. This observation is most notable when compared to exposure values obtained during the clearing of the other sulfuryl fluoride treated structure of similar terminal concentration (compare with study Site Number 3). In addition, an attempt was made to obtain measurements of the decreasing air concentration of sulfuryl fluoride within the tarpaulined structure during the operation of the fan. However, these attempts were not successful.

At the second and final house of the third study day (site 9) we again tried to reduce the terminal concentration while also directing the exhaust away from workers and other structures. At this site, the exhaust fan was set up at the rear of the house. An exhaust duct was made from plastic sheeting and attached to the exhaust side of the fan by clipping the plastic to the outside of the fan housing. This duct was designed to direct the fan exhaust up the side of the structure and exhaust the fumigant at roofline level to provide aeration up and away from workers and neighboring structures. With this method we hoped to avoid the problem of possible exposure to the crew from exhausting the fumigant observed on the first house. This fan was operated during the ground seal removal and continued until the tarpaulins were removed (approximately thirty minutes). This procedure provided the lowest worker exposure measurements observed for the ground seal step. During this step, two of the workers had no detectable exposure and one had less than one ppm. Worker exposure was also reduced during the clip removal/seam opening steps. All other worker exposure measurements were reduced with the exception of a five ppm exposure for one worker during tarpaulin folding.

To further examine the relation between exposure, time period of each step, and the concentration of remaining fumigant and to verify our observations, calculations were made from the data for each worker to produce values that could be easily compared. Calculations were made to obtain the time-weighted average (TWA) airborne concentration for all the monitored periods for each worker at each site. This TWA value should represent the total work effort in terms of a exposure-time factor for each worker to complete his task at each site. These values are shown graphically with individual ppm-minutes and with the time-weighted average (TWA) airborne concentration values (ppm-minutes divided by actual time) for each worker on pages 20 to 28. The TWAs are calculated for only the actual time measurements obtained and no zero concentration time is included in the calculations as would be done to compare a series of samples with an occupational exposure standard. For comparison, see calculation on page 6 where the balance of the time is considered to be at zero concentration. Also, on each graph is a dotted line at the label-mandated 5 ppm airborne level limit.

Table IV is a tabulation of all the individual values for all the sulfuryl fluoride treated fumigation sites. Table V is a tabulation of all the individual values for all the methyl bromide treated sites. Table VI is an overall summary with data from all sites included.

The average TWA value for the entire clearing crew at each site was then compared with the pre-clearing fumigant concentration to determine if our field observations of a relationship between these two measurements could be shown statistically. This correlation is shown graphically by Figure 1.

The test for positive linear correlation of the fumigant concentration remaining in the structure and the average TWA for the clearing crew for this data is not considered strong statistically with data from only 9 sites.<sup>5</sup> With the variability present in this data, a larger sample set would be needed to show a strong positive statistical correlation. Each fumigation site is unique and presents a wide variety of potential exposure conditions. In addition, although the terminal concentration of fumigant is the "cause" of the exposure, the volume and concentration of fumigant in the air between the tarpaulin and the structure may be more directly related to the exposure than the interior fumigant concentration. In spite of the above comments and in light of the unique conditions present at site 7, it is apparent from inspection of Figure 1 that the lower the fumigant concentration the lower the exposure to the clearing crew.

#### Fumigant Penetration of Bagged Foodstuffs.

Fumigant was found at varying concentrations inside all sealed bagged foodstuffs. This work has shown that the label-required bagging of food items may not be providing the protection intended by this practice. This was also found to be the case during an earlier study.<sup>1</sup> However, the earlier study looked only at methyl bromide treated structures. It is unclear if this contact with foodstuff poses any particular hazard, but it is clear that the bagging is not preventing contact as intended. No attempt was made to correlate fumigant found in bagged foodstuffs and ending fumigant concentration. Many times the levels were above the upper range of the Vikane detector (greater than 50 ppm). In some instances an attempt was made to analyze these higher levels with the Fumiscope. See Table VII for a compilation of the values from the various sites.

#### CONCLUSIONS

In conclusion, this pilot study has shown that current methods of clearing fumigated residential structures may not be providing adequate exposure mitigation to the workers involved in these operations. This study has also found a possible method of reducing worker exposure during these operations that appears to be practical and might be readily acceptable to the fumigation industry. This method involves reducing the concentration of fumigant remaining in the structure (terminal concentration) and evacuating the air space between the tarpaulin and the outside of the structure. Using existing industry equipment, the remaining fumigant concentration can be lowered by positive aeration of the tarpaulined structure prior to the start of the clearing procedures. The results of this pilot study, showing the relation of the ending concentration and worker exposure, will be shared with the fumigation industry and used to direct future studies toward developing a standard method of clearing structures. The results of the bagged foodstuff monitoring will be used to direct industry research in development of methods of minimizing contact of fumigant with foodstuffs.

STUDY SITE NUMBER: 1

SITE LOCATION: 3761 Olive, Long Beach

DATE: October 13, 1987

COMPANY NAME: Division of Fumigation

EPA PRODUCT NO: 464 236 - VIKANE

STRUCTURE VOLUME: 32,000 ft<sup>3</sup>

APPLICATION: 17 pounds plus 2.5 ounces chloropicrin (~ 2100 ppm)

FUMIGATION TIME: 24 hours

STRUCTURE DESCRIPTION: one story "ranch style" fairly flat roof

FUMIGANT CONCENTRATION INSIDE TARPAULIN PRIOR TO START OF CLEARANCE  
PROCEDURES: (from fumiscope) 6 oz/1000 ft<sup>3</sup> (~ 1500 ppm)

ENVIRONMENTAL CONDITIONS: Temp: 68, Wind speed/direction: none

COMMENTS: Water snake seal around building. Tarpaulin had a two-foot tear on front, patched with duct tape. 43 ppm measured inside of bag containing salt, baking soda, bag was sealed.

MONITORING INFORMATION:

TASK/WORKER	START	STOP	TIME (min)	CONCENTRATION (ppm)	COMMENTS/NOTES
"A"					
Ground Seal(GS)	0940	0945	5	2	
Clip Removal(CR)	0949				together with SO
Seam Opening(SO)		0953	4	6	
Shrubbery(S)	1007				together with PT
Peel Tarps(PT)		1010	3	3	2nd bag, 1st bag broke
Fold Tarps(FT)	1017	1030	13	0.5	
"B"					
Ground Seal	0940	0945	5	< 2	
Clip Removal	0949				together with SO
Seam Opening		0954	5	5.5	
Shrubbery	0959	1003	4	0.5	
Peel Tarps	1007	1010	3	3	
Fold Tarps	1017	1030	13	0.5	
"C"					
Ground Seal	0940	0945	5	2	
Clip Removal	0950				together with SO
Seam Opening		0955	5	1	
Shrubbery					
Peel Tarps	0959	1007	8	< 1	two bags
	1007	1010	3	2	worked on roof
Fold Tarps	1017	1030	13	1.5	

STUDY SITE NUMBER: 2

SITE LOCATION: 7582 Vantage Dr., Huntington Beach

DATE: October 13, 1987

COMPANY NAME: Barden's Pest Control, Rousselle Fumigators, Inc

EPA PRODUCT NO: 464 236 - VIKANE

STRUCTURE VOLUME: 25,000 ft<sup>3</sup>

APPLICATION RATE: 20 pounds (13 oz/1000ft<sup>3</sup>), (3250 ppm)

FUMIGATION TIME: 25 hours

STRUCTURE DESCRIPTION: single story, attached garage

FUMIGANT CONCENTRATION INSIDE TARPAULIN PRIOR TO START OF CLEARANCE  
PROCEDURES: 9 ounces/1000 ft<sup>3</sup> (~ 2250 ppm)

ENVIRONMENTAL CONDITIONS: Temp 68° F, Wind speed/direction 5-8 SE

MONITORING INFORMATION:

TASK/WORKER	START	STOP	TIME (min)	CONCENTRATION (ppm)	COMMENTS/NOTES
"A"					
Ground Seal	1200	1204	4	7.5	
Clip Removal	1205				
Seam Opening		1210	5	> 50	together with SO opened most of clips
Shrubbery	1215				
Peel Tarps		1220	5	47	
Fold Tarps	1225	1227	2	2	walked thru patio partially covered
Open Garage Door			< 1	8-9	
"B"					
Ground Seal	1200	1204	4	0.5	
Clip Removal	1208				sand snakes together with SO
Seam Opening		1212	4	10.5	
Shrubbery	1215				
Peel Tarps		1225	10	6	together with PT
Fold Tarps	1225	1237	12	< 1	
"C"					
Ground Seal	1200	1204	4	0.5	
Clip Removal	1207				sand snakes together with SO
Seam Opening		1215	8	2	
Shrubbery	1215				
Peel Tarps		1225	10	3.5	together with PT
Fold Tarps	1225	1237	12	< 2	

STUDY SITE NUMBER: 3

SITE LOCATION: 4853 Middleberry Court, Cypress

DATE: October 13, 1987

COMPANY NAME: Admiral Pest Control

EPA PRODUCT NO: 464 236 - VIKANE

STRUCTURE VOLUME: 33,000 ft<sup>3</sup>

APPLICATION RATE: 40 pounds (19 oz/1000 ft<sup>3</sup>), (4750 ppm)

STRUCTURE DESCRIPTION: split level with attached garage, raised foundation

FUMIGATION TIME: 26 hours

FUMIGANT CONCENTRATION INSIDE TARPAULIN PRIOR TO START OF CLEARANCE  
PROCEDURES: 8 ounces/1000 ft<sup>3</sup> (~ 2000 ppm)

ENVIRONMENTAL CONDITIONS: Temp - 81°F, RH - 53%

COMMENTS: Tarpaulin had quite a few patches and large rip in the top. Vertical clips released and tarp blowing around. Ground workers may have been exposed to additional Vikane. More than 50 ppm inside bagged and duct-taped bag; after about 10 minutes - still greater than 50 ppm. Bag removed from freezer - greater than 50 ppm; after about 10 minutes - still greater than 50 ppm. Bagged food after about twenty minutes - 4 ounces/1000 ft<sup>3</sup> (~ 1000 ppm) measured with fumiscope.

MONITORING INFORMATION:

TASK/WORKER	START	STOP	TIME (min)	CONCENTRATION (ppm)	COMMENTS/NOTES
"A"					
Ground Seal	1417	1433	16	11.5	together with PT
Shrubbery	1440				
Peel Tarps		1455	15	15.5	
Fold Tarps	1456	1513	17	ND	
"B"					
Ground Seal	1417	1433	16	19	worked on roof together with PT
Shrubbery	1440				
Peel Tarps		1455	15	10	
Fold Tarps	1456	1512	16	ND	
"C"					
Clip Removal	1417	1432	15	3.5	removed most clips removed roof clips wearing SCBA
Roof Clips	1434	1458	24	10	
Opening House	1508	1515	7	> 50	

STUDY SITE NUMBER: 2

SITE LOCATION: 7582 Vantage Dr., Huntington Beach

DATE: October 13, 1987

COMPANY NAME: Barden's Pest Control, Rousselle Fumigators, Inc

EPA PRODUCT NO: 464 236 - VIKANE

STRUCTURE VOLUME: 25,000 ft<sup>3</sup>

APPLICATION RATE: 20 pounds (13 oz/1000ft<sup>3</sup>), (3250 ppm)

FUMIGATION TIME: 25 hours

STRUCTURE DESCRIPTION: single story, attached garage

FUMIGANT CONCENTRATION INSIDE TARPAULIN PRIOR TO START OF CLEARANCE  
PROCEDURES: 9 ounces/1000 ft<sup>3</sup> (~ 2250 ppm)

ENVIRONMENTAL CONDITIONS: Temp 68° F, Wind speed/direction 5-8 SE

MONITORING INFORMATION:

TASK/WORKER	START	STOP	TIME (min)	CONCENTRATION (ppm)	COMMENTS/NOTES
"A"					
Ground Seal	1200	1204	4	7.5	
Clip Removal	1205				together with SO
Seam Opening		1210	5	> 50	opened most of clips
Shrubbery	1215				
Peel Tarps		1220	5	47	walked thru patio
Fold Tarps	1225	1227	2	2	partially covered
Open Garage Door			< 1	8-9	
"B"					
Ground Seal	1200	1204	4	0.5	sand snakes
Clip Removal	1208				together with SO
Seam Opening		1212	4	10.5	
Shrubbery	1215				together with PT
Peel Tarps		1225	10	6	
Fold Tarps	1225	1237	12	< 1	
"C"					
Ground Seal	1200	1204	4	0.5	sand snakes
Clip Removal	1207				together with SO
Seam Opening		1215	8	2	
Shrubbery	1215				together with PT
Peel Tarps		1225	10	3.5	
Fold Tarps	1225	1237	12	< 2	

STUDY SITE NUMBER: 3

SITE LOCATION: 4853 Middleberry Court, Cypress

DATE: October 13, 1987

COMPANY NAME: Admiral Pest Control

EPA PRODUCT NO: 464 236 - VIKANE

STRUCTURE VOLUME: 33,000 ft<sup>3</sup>

APPLICATION RATE: 40 pounds (19 oz/1000 ft<sup>3</sup>), (4750 ppm)

STRUCTURE DESCRIPTION: split level with attached garage, raised foundation

FUMIGATION TIME: 26 hours

FUMIGANT CONCENTRATION INSIDE TARPAULIN PRIOR TO START OF CLEARANCE PROCEDURES: 8 ounces/1000 ft<sup>3</sup> (~ 2000 ppm)

ENVIRONMENTAL CONDITIONS: Temp - 81°F, RH - 53%

COMMENTS: Tarpaulin had quite a few patches and large rip in the top. Vertical clips released and tarp blowing around. Ground workers may have been exposed to additional Vikane. More than 50 ppm inside bagged and duct-taped bag; after about 10 minutes - still greater than 50 ppm. Bag removed from freezer - greater than 50 ppm; after about 10 minutes - still greater than 50 ppm. Bagged food after about twenty minutes - 4 ounces/1000 ft<sup>3</sup> (~ 1000 ppm) measured with fumiscope.

#### MONITORING INFORMATION:

TASK/WORKER	START	STOP	TIME (min)	CONCENTRATION (ppm)	COMMENTS/NOTES
"A"					
Ground Seal	1417	1433	16	11.5	together with PT
Shrubbery	1440				
Peel Tarps		1455	15	15.5	
Fold Tarps	1456	1513	17	ND	
"B"					
Ground Seal	1417	1433	16	19	worked on roof together with PT
Shrubbery	1440				
Peel Tarps		1455	15	10	
Fold Tarps	1456	1512	16	ND	
"C"					
Clip Removal	1417	1432	15	3.5	removed most clips removed roof clips wearing SCBA
Roof Clips	1434	1458	24	10	
Opening House	1508	1515	7	> 50	

STUDY SITE NUMBER: 4

SITE LOCATION: 3123 Rome, Anaheim

DATE: October 13, 1987

COMPANY NAME: Division of Fumigation

EPA PRODUCT NO: 464 236 - VIKANE

STRUCTURE VOLUME: 36,000 ft<sup>3</sup>

APPLICATION RATE: 17 pounds (7 oz/1000 ft<sup>3</sup>), (~ 1800 ppm)

FUMIGATION TIME: 23 hours

STRUCTURE DESCRIPTION: single story with attached garage, slab floor

FUMIGANT CONCENTRATION INSIDE TARPAULIN PRIOR TO START OF CLEARANCE PROCEDURES: 4 ounces/1000 ft<sup>3</sup> (~ 1000 ppm)

ENVIRONMENTAL CONDITIONS: Temp - 81°F, Wind speed/direction - calm, RH - 61%

COMMENTS: dropped back tarpaulin first (upwind side of house). Bag from refrigerator - 32 oz/1000 ft<sup>3</sup> (~ 8,000 ppm)

**MONITORING INFORMATION:**

TASK/WORKER	START	STOP	TIME (min)	CONCENTRATION (ppm)	COMMENTS/NOTES
<b>"A"</b>					
Ground Seal	1636	1641	5	4	
Clip Removal	1641				together with SO
Seam Opening		1650	9	1.5	
Shrubbery	1650				together with PT
Peel Tarps		1700	10	1	
Fold Tarps	1700	1720	20	1.5	
<b>"B"</b>					
Ground Seal	1636	1641	5	2	
Clip Removal	1641				together with SO
Seam Opening		1650	9	1.5	
Shrubbery	1650				together with PT
Peel Tarps		1700	10	1	
Fold Tarps	1700	1720	20	2.25	
<b>"C"</b>					
Ground Seal					not involved
Clip Removal	1639				together with SO
Seam Opening		1650	11	2.5	worked on roof
Shrubbery					
Peel Tarps	1650	1703	13	2	worked on roof
Fold Tarps					



STUDY SITE NUMBER: 5

SITE LOCATION: 2544 W. Roven St., Anaheim

DATE: October 14, 1987

COMPANY NAME: O'Brien Exterminating

EPA PRODUCT NO: 8536-12 - METHYL BROMIDE

STRUCTURE VOLUME: 20,000 ft<sup>3</sup>

APPLICATION RATE: 30 pounds (~ 6000 ppm)

FUMIGATION TIME: 22 hours

STRUCTURE DESCRIPTION: One story house on raised foundation, with flat roof

FUMIGANT CONCENTRATION INSIDE TARPAULIN PRIOR TO START OF CLEARANCE  
PROCEDURES: 6 ounces/1000 ft<sup>3</sup> (~ 1500 ppm)

ENVIRONMENTAL CONDITIONS: Temp - 68°F, RH - 72%

COMMENTS: freezer bag - 2 oz/1000 ft<sup>3</sup> (~ 500 ppm), bagged food 6 oz/1000  
ft<sup>3</sup>(~ 1500ppm)

MONITORING INFORMATION:

TASK/WORKER	START	STOP	TIME (min)	CONCENTRATION (ppm)	COMMENTS/NOTES
"A"					
Ground Seal	0840	0845	5	2.1	
Clip Removal	0850				together with SO
Seam Opening		0852	2	3.2	Draeger - ND
Shrubbery	0855				together with PT
Peel Tarps		0900	5	6.4	Draeger - ND
Fold Tarps	0904	0915	11	ND	
"B"					
Ground Seal	0840	0845	5	1.1	
Clip Removal	0848				together with SO
Seam Opening		0850	2	3.2	
Shrubbery	0855				together with PT
Peel Tarps		0900	5	4.3	
Fold Tarps	0904	0915	11	0.5	
"C"					
Ground Seal	0840	0845	5	ND	
Clip Removal	0848				together with SO
Seam Opening		0850	2	6.4	
Shrubbery	0855				together with PT
Peel Tarps		0900	5	2.1	Draeger - ND
Going inside	0904	0911	7	205	Draeger > 100 (wearing SCBA)

STUDY SITE NUMBER: 6

SITE LOCATION: 9522 Drumbeat Circle, Huntington Beach

DATE: October 14, 1987

COMPANY NAME: O'Brien Exterminators

EPA PRODUCT NO: - METHYL BROMIDE

STRUCTURE VOLUME: 38,000 ft<sup>3</sup>

APPLICATION RATE: 57 pounds with 0.5% chloropicrin ( ~ 6000 ppm)

FUMIGATION TIME: 22.5 hours

STRUCTURE DESCRIPTION: split level, attached garage on slab foundation

FUMIGANT CONCENTRATION INSIDE TARPAULIN PRIOR TO START OF CLEARANCE  
PROCEDURES: 3 ounces/1000 ft<sup>3</sup> ( ~ 750 ppm)

ENVIRONMENTAL CONDITIONS: Temp - 73-77°F, RH - 60-68%

MONITORING INFORMATION:

TASK/WORKER	START	STOP	TIME (min)	CONCENTRATION (ppm)	COMMENTS/NOTES
<b>"A"</b>					
Ground Seal	1031	1037	6	1.4	
Clip Removal	1037				together with SO
Seam Opening		1050	13	0.5	
Shrubbery					
Peel Tarps	1050				together with FT
Fold Tarps		1119	29	0.7	
<b>"B"</b>					
Ground Seal	1031	1037	6	1.4	
Clip Removal	1037				together with SO
Seam Opening		1058	21	2.8	Draeger < 3, worked on roof
Shrubbery					
Peel Tarps					
Fold Tarps	1100	1103	3		together with -
Entering House	1104	1109	5	56.8	Draeger ~ 80 w/SCBA
Fold Tarps	1111	1125	14	1.4	
<b>"C"</b>					
Ground Seal	1031	1037	6	0.4	
Clip Removal	1037				together with SO
Seam Opening		1058	21	5.2	Draeger ~ 3 worked on roof
Shrubbery					
Peel Tarps	1100				together with PT
Fold Tarps		1117	17	0.5	

STUDY SITE NUMBER: 7

SITE LOCATION: 3706 Channel Place, Newport

DATE: October 14, 1987

COMPANY NAME: Newport Exterminating

EPA PRODUCT NO: - METHYL BROMIDE

STRUCTURE VOLUME: 33,000 ft<sup>3</sup>

APPLICATION RATE: 55 pounds (0.5% chloropicrin) ( ~ 6,600 ppm)

FUMIGATION TIME: 23.5 hours

STRUCTURE DESCRIPTION: two story square home on 30 x 50 lot on slab

FUMIGANT CONCENTRATION INSIDE TARPAULIN PRIOR TO START OF CLEARANCE  
PROCEDURES: 84.9 ppm

ENVIRONMENTAL CONDITIONS: Temp - 76°F, RH - 58%

COMMENTS: Tarpaulin ripped about eight feet from roof during the unclipping.  
Rip about six feet in length. House on small lot at harbor with other  
similar two-story houses on either side. Bag from refrigerator - 228 ppm,  
tuna fish from refrigerator - 11.5 ppm.

MONITORING INFORMATION:

TASK/WORKER	START	STOP	TIME (min)	CONCENTRATION (ppm)	COMMENTS/NOTES
"A"					
Ground Seal	1255				together with CR
Clip Removal					together with SO
Seam Opening		1310	15	9.6	Draeger ~ 6
Shrubbery					worked on roof
Peel Tarps					
Fold Tarps	1313	1321	8	0.4	
"B"					
Ground Seal	1255				together with CR
Clip Removal					together with SO
Seam Opening		1310	15	3.4	Draeger - < 1
Peel Tarps					
Fold Tarps	1313	1328	15	0.4	
"C"					
Ground Seal	1255				together with CR
Clip Removal					together with SO
Seam Opening		1310	15	4.2	Draeger ~ 3
Peel Tarps					
Fold Tarps	1313	1328	15	0.4	

STUDY SITE NUMBER: 8

SITE LOCATION: 337 W. 7th, Long Beach

DATE: October 15, 1987

COMPANY NAME: Fume Works Inc.

EPA PRODUCT NO: 464 236 - VIKANE

STRUCTURE VOLUME: 33,000 ft<sup>3</sup>

FUMIGATION TIME: 24 hours

APPLICATION RATE: 30 pounds with 2 ounces of chloropicrin. ( ~ 3,600 ppm)

STRUCTURE DESCRIPTION: one story with detached garage

FUMIGANT CONCENTRATION INSIDE TARPAULIN PRIOR TO START OF CLEARANCE  
PROCEDURES: 8 ounces/1000 ft<sup>3</sup> (2000 ppm)

COMMENTS: Temp - 72°F, RH - 64%. Fan installed on front of house exhausting outwardly. Started during the beginning of the snake removal at 0857. Fan ran until 0925. Capacity of fan - 4000 ft<sup>3</sup>/minute. Significant exposures probably a result of position of exhausting fan. Most of fumigant was exhausted toward the position of the fumigator's truck. Ground seal removal values affected. At this site three sampling lines were installed in the structure. Number 1 sampling line inlet was on the front porch. Number 2 was inside living room area. At 0950 number 2 line was ~ 1 ounce/1000 ft<sup>3</sup>, (250 ppm). Number 3 was between the house and the tarpaulin.

#### MONITORING INFORMATION:

TASK/WORKER	START	STOP	TIME (min)	CONCENTRATION (ppm)	COMMENTS/NOTES
<b>"A"</b>					
Ground Seal	0857	0905	8	6	Tri-Cal - 6
Clip Removal	0925				together with SO
Seam Opening		0931	6	6	Tri-Cal - 5
Shrubbery	0932				together with PT
Peel Tarps		0942	10	1.5	Tri-Cal - 1
Fold Tarps	0945	1006	21	< 1	Tri-Cal < 1
<b>"B"</b>					
Ground Seal	0857	0905	8	12.5	Tri-Cal - 11.5
Clip Removal	0925				together with SO
Seam Opening		0931	6	3	Tri-Cal - 2.5
Shrubbery	0932				together with PT
Peel Tarps		0942	10	2	Tri-Cal - 2
Fold Tarps	0945	1006	21	< 1	Tri-Cal < 1
<b>"C"</b>					
Ground Seal	0857	0905	8	11.5	Tri-Cal - 10.5
Clip Removal	0925				together with SO
Seam Opening		0931	6	1	Tri-Cal - 1
Shrubbery	0932				together with PT
Peel Tarps		0942	10	1	Tri-Cal - 1
Fold Tarps	0945	1006	21	< 1	Tri-Cal < 1

STUDY SITE NUMBER: 9

SITE LOCATION: 5331 Daggett, Long Beach

DATE: October 15, 1987

COMPANY NAME: Rousselle - Barden's Pest Control

EPA PRODUCT NO: 464 236 - VIKANE

STRUCTURE VOLUME: 18,000 ft<sup>3</sup>

FUMIGATION TIME: 24 hours

APPLICATION RATE: 14 pounds (12 oz/1000 ft<sup>3</sup>), ( ~ 3000 ppm)

STRUCTURE DESCRIPTION: single story attached garage

FUMIGANT CONCENTRATION INSIDE TARPAULIN PRIOR TO START OF CLEARANCE  
PROCEDURES: 5 ounces/1000 ft<sup>3</sup> ( ~ 1250 ppm)

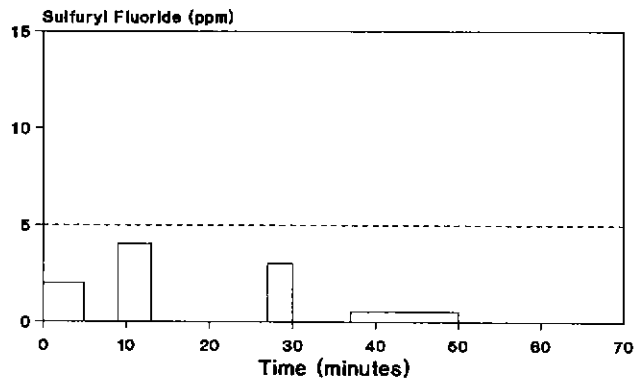
COMMENTS: Temp 73°F, Wind speed/direction - nil, RH - 64%. Exhaust fan set up in rear of house with plastic sheeting designed as duct and positioned up the side of the structure to direct aeration up and away from workers/other houses. Fan started at 1137, after only the back of the house was un-snaked. Fumigation started at 1500 on October 14.

MONITORING INFORMATION:

TASK/WORKER	START	STOP	TIME (min)	CONCENTRATION (ppm)	COMMENTS/NOTES
"A"					
Ground Seal	1132	1137			together with
	1139	1141	7	ND	
Clip Removal	1143	1150			together with
	1151				together with SO
Seam Opening		1155	11	5	
Shrubbery	1155				together with PT
Peel Tarps		1208	13	ND	
Fold Tarps	1208	1218	10	5	
"B"					
Ground Seal	1132	1137			together with
	1138	1141	8	ND	same bag
Clip Removal	1143	1150			together with
	1151				together with SO
Seam Opening		1155	11	1.5	worked on roof
Shrubbery	1155				together with PT
Peel Tarps		1208	8	< 1	
Fold Tarps	1208	1225	17	1	
"C"					
Ground Seal	1132	1137			together with
	1138	1141	8	< 1	worked on roof
Clip Removal	1151				together with SO
Seam Opening		1155	4	< 1	
Shrubbery	1155				together with PT
Peel Tarps		1208	13	1	
Fold Tarps	1208	1225	17	2.5	

# SITE 1

worker A

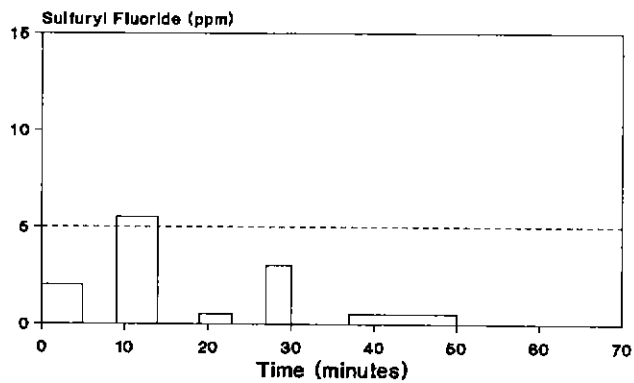


ppm-minutes TWA

49

2.0

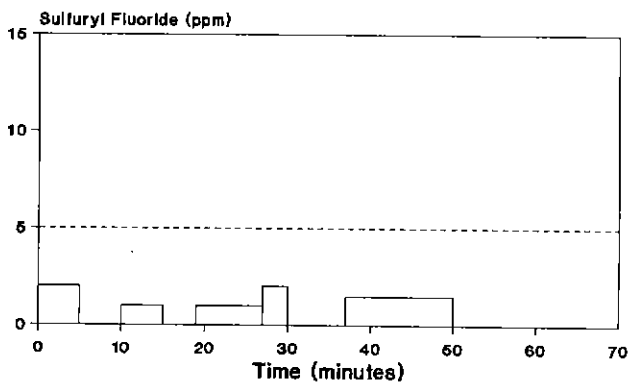
worker B



55

1.7

worker C

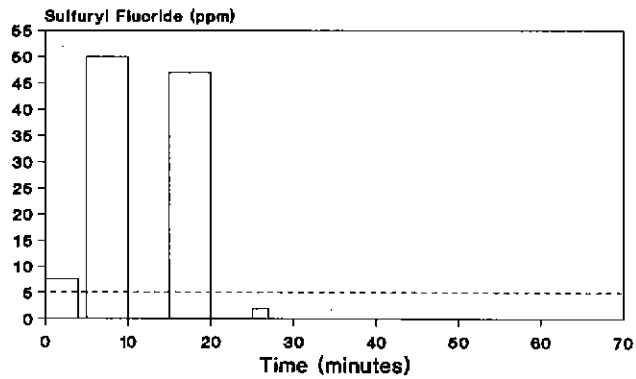


49

1.4

## SITE 2

worker A

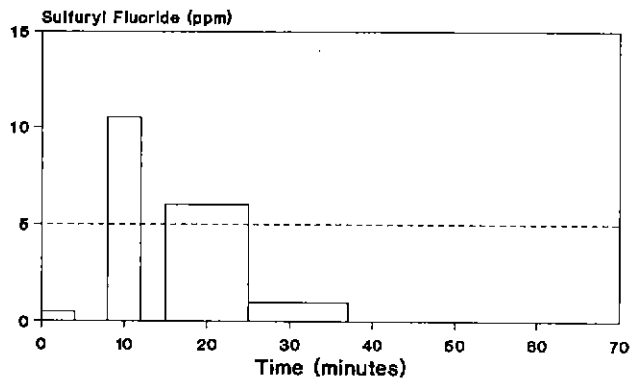


ppm-minutes TWA

519

32.4

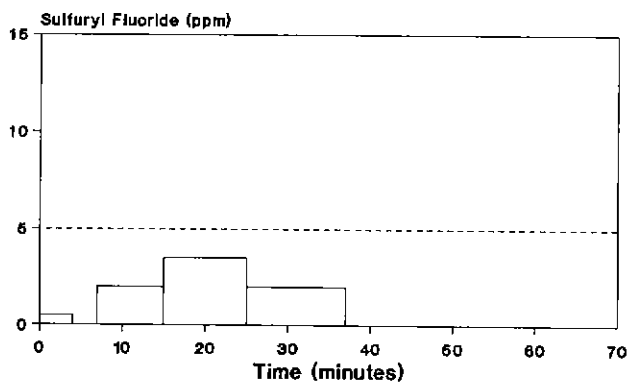
worker B



116

3.9

worker C

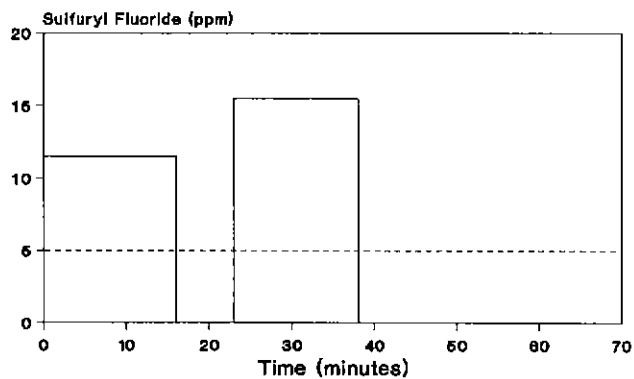


77

2.3

## SITE 3

worker A

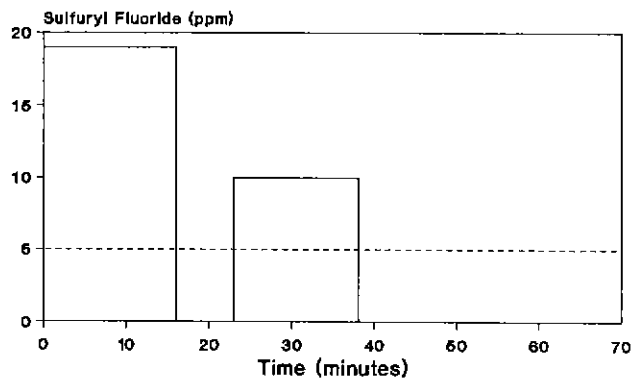


ppm-minutes TWA

416

8.7

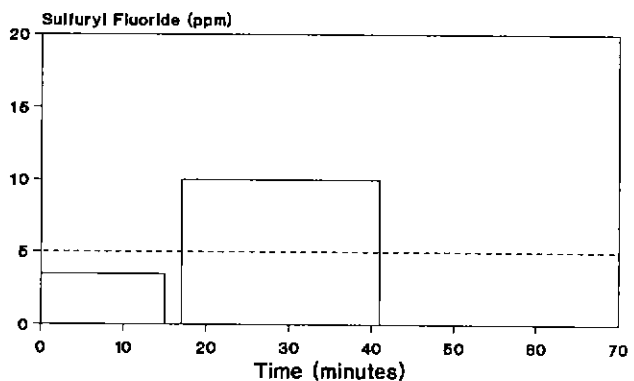
worker B



454

9.6

worker C



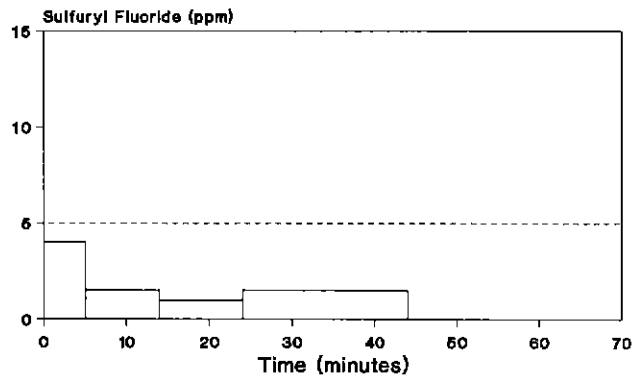
292

7.5



# SITE 4

worker A

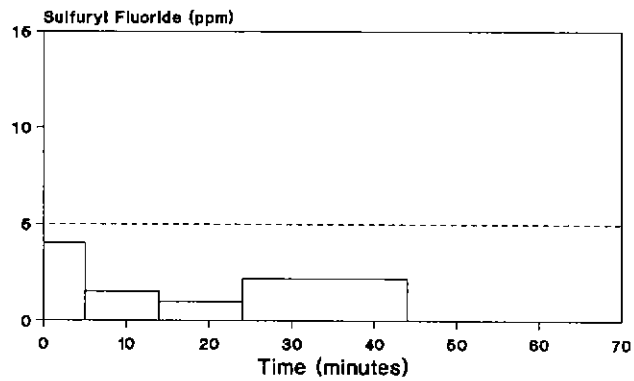


ppm-minutes TWA

74

1.7

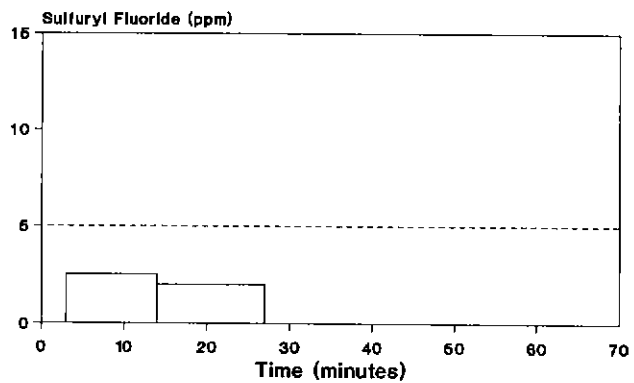
worker B



78

1.8

worker C

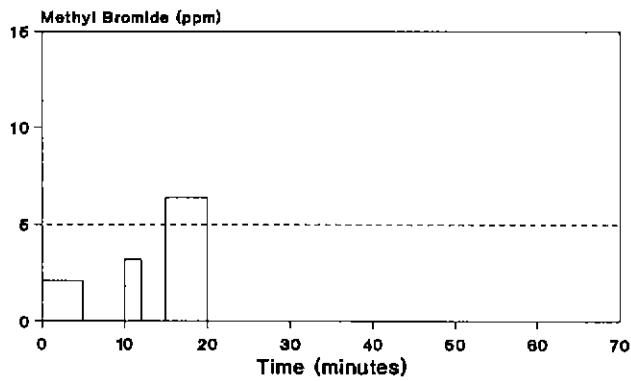


54

2.2

# SITE 5

worker A

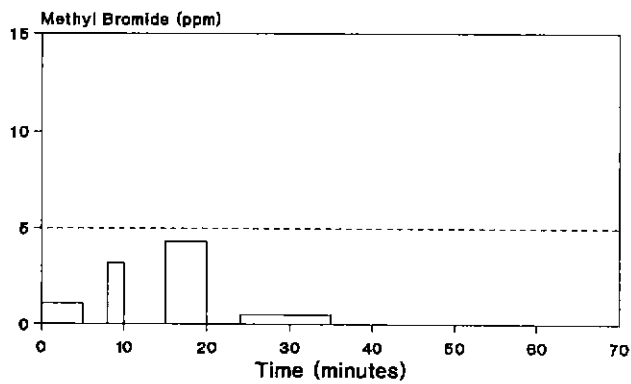


ppm-minutes      TWA

49.2

2.1

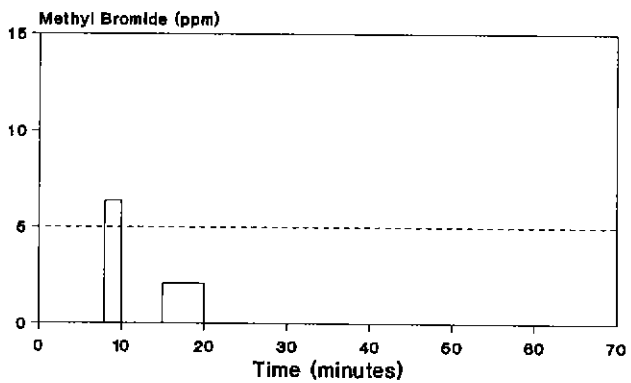
worker B



39.1

1.7

worker C

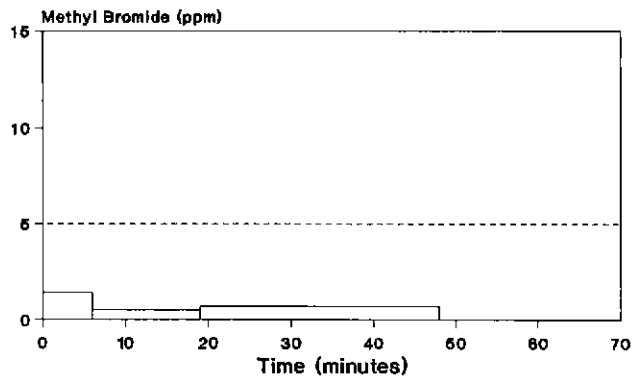


23.5

2.0

# SITE 6

worker A

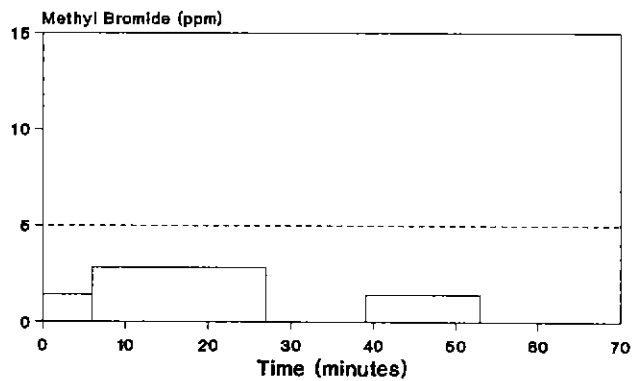


ppm-minutes TWA

36.5

0.8

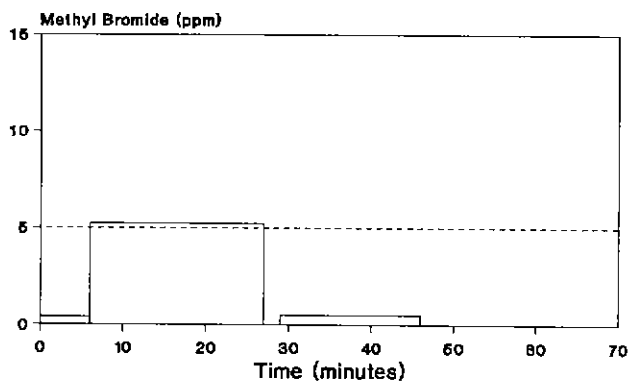
worker B



88.3

2.2

worker C

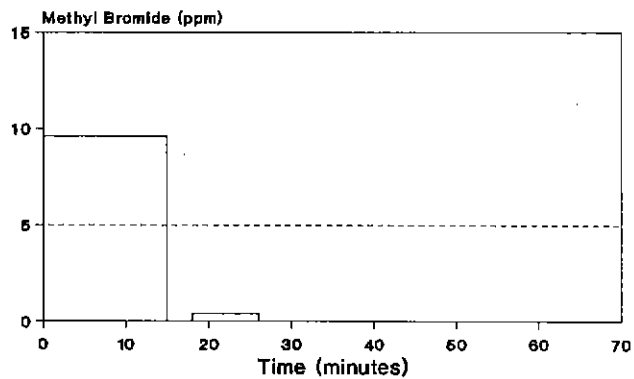


121.0

2.8

# SITE 7

worker A

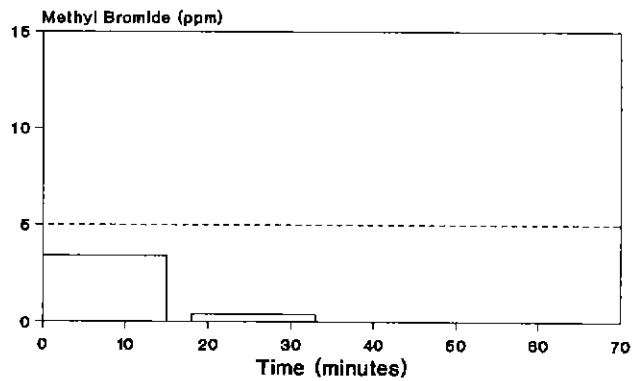


ppm-minutes TWA

146.9

6.4

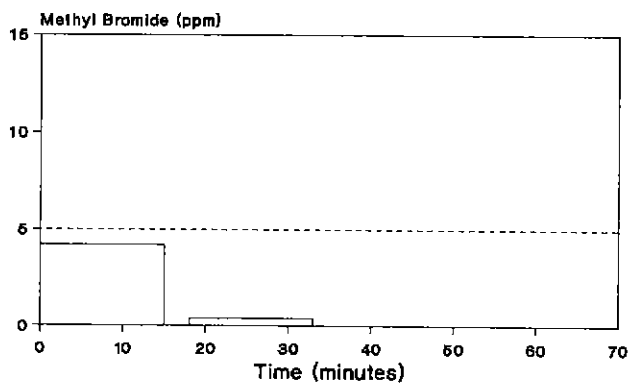
worker B



57.8

1.9

worker C

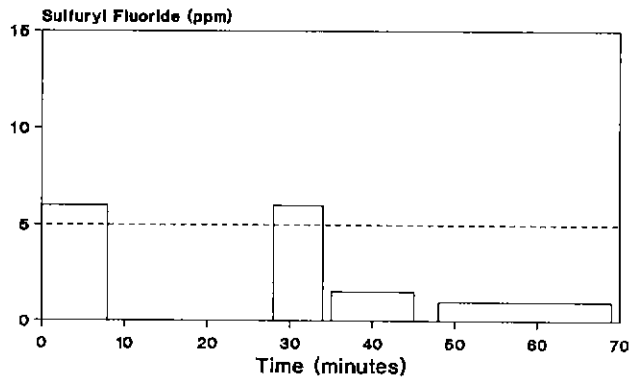


68.4

2.3

# SITE 8

worker A

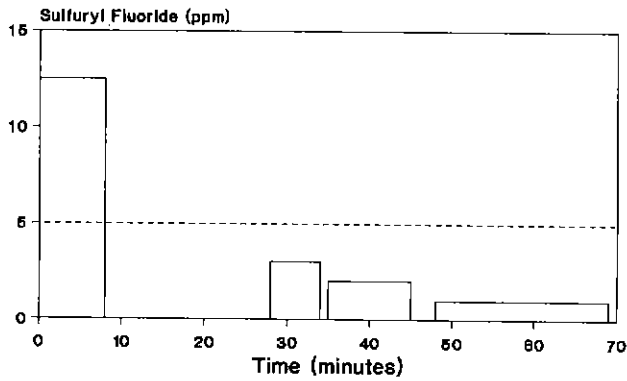


ppm-minutes TWA

120

2.7

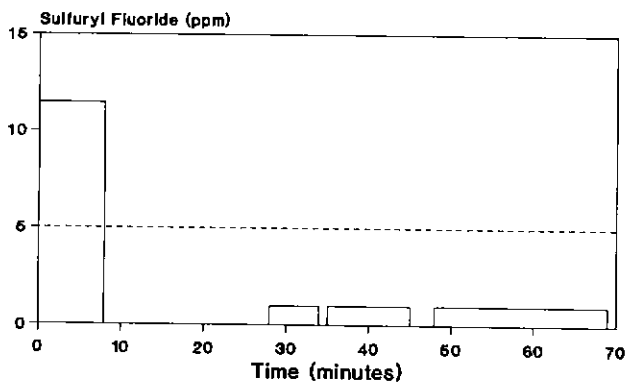
worker B



159

3.5

worker C

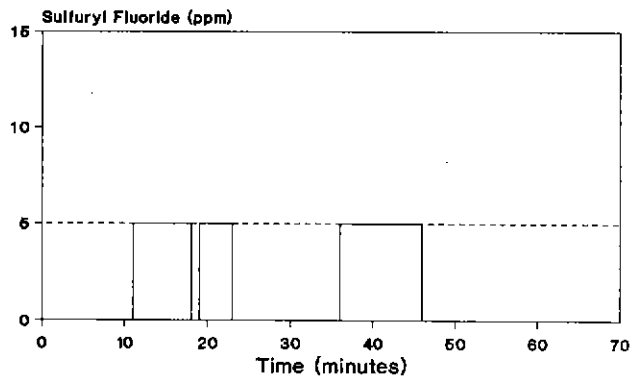


129

2.9

# SITE 9

worker A

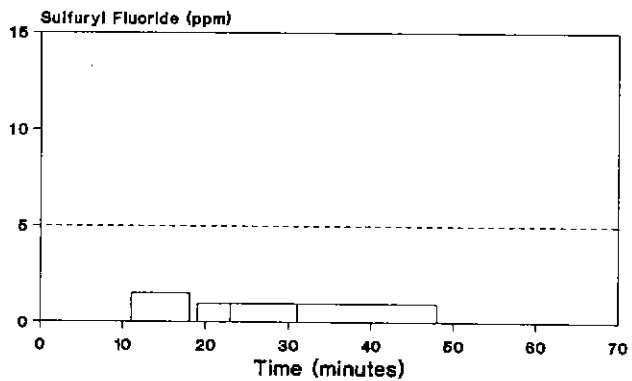


ppm-minutes TWA

105

2.6

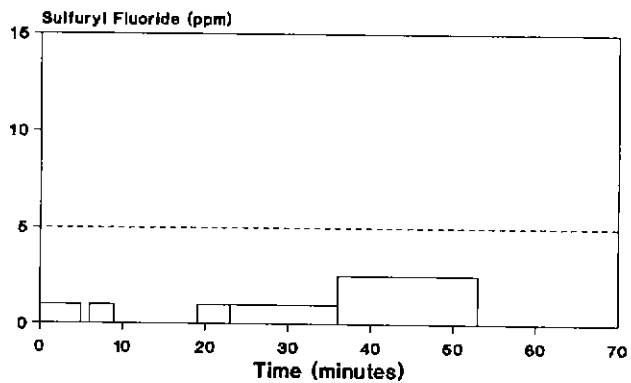
worker B



41

0.9

worker C



67

1.6

TABLE II

Comparison of Data from Sulfuryl Fluoride Treated Sites  
with Highest Observed Exposure (Worst Case) per Task per Site

Site	Volume (ft <sup>3</sup> )	Time (hrs)	App Conc (ppm)	Term Conc (ppm)	GS (ppm)	CR/SO (ppm)	S/PT (ppm)	FT (ppm)
1	32,000	24	2100	1500	2	6	3	2
2	25,000	25	3250	2250	8	50	47	6
3	33,000	26	4750	2000	19	10	16	ND
4	36,000	23	1800	1000	4	2	2	2
8	33,000	24	3600	2000	12	6	2	1
9	18,000	24	3000	1250	1	5	1	5

Above data arranged by decreasing terminal concentration:

2	25,000	25	3250	2250	8	50	47	6
3	33,000	26	4750	2000	19	10	16	ND
8	33,000	24	3600	2000	12	6	2	1
1	32,000	24	2100	1500	2	6	3	2
9	18,000	24	3000	1250	1	5	1	5
4	36,000	23	1800	1000	4	2	2	2

TABLE III

Comparison of Data from Methyl Bromide Treated Structures  
with Highest Observed Exposure (Worst Case) per Task per Site

Site	Volume (ft <sup>3</sup> )	Time (hrs)	App Conc (ppm)	End Conc (ppm)	GS (ppm)	CR/SO (ppm)	S/PT (ppm)	FT (ppm)
5	20,000	22	6000	1500	2	6	6	<1
6	38,000	22	6000	750	1	5	1	1
7	33,000	24	6600	85	-	10	-	1

TABLE IV

## Comparison of Data from Sulfuryl Fluoride Treated Structures

Worker Exposure To Sulfuryl Fluoride During Specific Tasks by  
Time to Accomplish Each Task Times Exposure Measurement  
and Individual Time-Weighted Average (TWA) Exposure  
(Arranged by Decreasing Terminal Concentrations)

Site	Term Conc (ppm)	Worker	Total Time (minutes)	GS	Tasks		FT	Exp x Time (ppm-min) Total/wkr	TWA/ worker (ppm)
					CR/SO (ppm-minutes)	S/PT			
2	2250	A	16	30	250	235	4	519	32.4
		B	30	2	42	60	12	116	3.9
		C	34	2	16	35	24	77	2.3
3	2000	A	48	184	-	232	ND	416	8.7
		B	47	304	-	150	ND	454	9.6
		C	39	-	292	-	-	292	7.5
8	2000	A	45	48	36	15	21	120	2.7
		B	45	100	18	20	21	159	3.5
		C	45	92	6	10	21	129	2.9
1	1500	A	25	10	24	9	6	49	2.0
		B	30	10	28	11	6	55	1.7
		C	34	10	5	14	20	49	1.4
9	1250	A	41	ND	55	ND	50	105	2.6
		B	44	ND	16	8	17	41	0.9
		C	42	8	4	13	42	67	1.6
4	1000	A	44	20	14	10	35	74	1.7
		B	44	10	14	10	45	78	1.8
		C	24	-	28	26	-	54	2.2



TABLE V

## Comparison of Data from Methyl Bromide Treated Structures

Worker Exposure During Specific Tasks by  
Time to Accomplish Each Task Times Exposure Measurement  
and Individual Time-Weighted Average (TWA) Exposure  
(Arranged by Decreasing Terminal Concentrations)

Site	Term Conc (ppm)	Worker	Total Time (minutes)	Tasks			FT	Exp x Time (ppm-min) Total/wkr	TWA/ worker (ppm)
				GS	CR/SO	S/PT			
5	1500	A	23	10.7	6.4	32.1	ND	49.2	2.1
		B	23	5.4	6.4	21.4	5.9	39.1	1.7
		C	12	ND	12.8	10.7	-	23.5	2.0
6	750	A	48	8.6	7.0	c	20.9	36.5	0.8
		B	41	8.6	59.4	c	20.2	88.3	2.2
		C	44	2.2	109.6	c	9.2	121.0	2.8
7	85	A	23	c	c	144.0	2.9	146.9	6.4
		B	30	c	c	51.0	6.8	57.8	1.9
		C	30	c	c	63.0	5.4	68.4	2.3

Notes: c designates a task combined with the next task during monitoring.

TABLE VI

## Comparison of all Fumigation Sites

Comparison of all Data for all Workers with Total Times for Tasks,  
 Exposure Multiplied by Time and Average Time-Weighted Average  
 Exposure for All Workers Involved at Each Site.  
 (Arranged by Decreasing Terminal Concentration)

Site	Fumigant	Term Conc (ppm)	Time Monitored Total (min)	ppm-min Total	TWA (ppm)
2	sulfuryl fluoride	2250	80	712	8.9
3	sulfuryl fluoride	2000	134	1162	8.7
8	sulfuryl fluoride	2000	135	408	3.0
1	sulfuryl fluoride	1500	89	153	1.7
5	methyl bromide	1500	58	112	1.9
9	sulfuryl fluoride	1250	127	213	1.7
4	sulfuryl fluoride	1000	112	206	1.8
6	methyl bromide	750	133	246	1.8
7	methyl bromide	85	83	273	3.3

TABLE VII

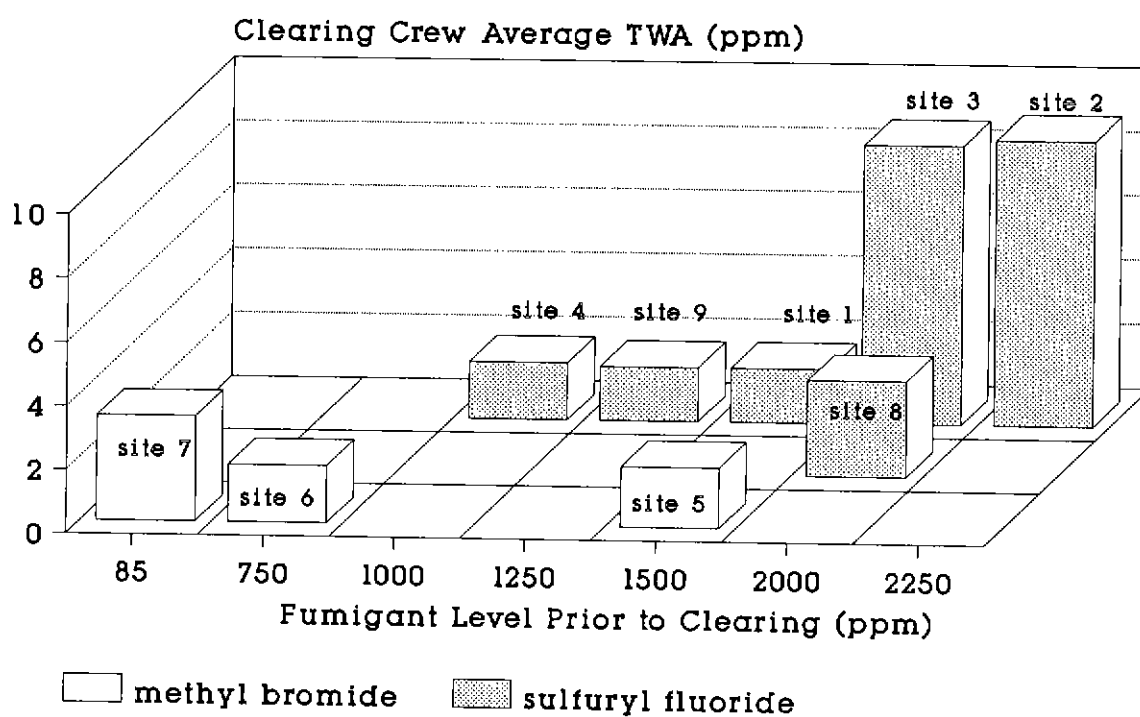
Fumigant Measured Inside Bagged Foodstuffs  
Arranged by Decreasing Concentration for all Sites

Site	Fumigant	Fumigant Concentration Measured (ppm)	Comment/Description
2	sulfuryl fluoride	-	no samples obtained
3	sulfuryl fluoride	>50*	duct taped bag
		>50*	same bag after 10 min
		~1000	same bag, 20 min, fumiscope measurement
		>50*	bag from freezer
		>50*	same bag after 10 min
8	sulfuryl fluoride	-	no samples obtained
1	sulfuryl fluoride	43	bag containing salt, baking soda, sealed
5	methyl bromide	~500	freezer bag, fumiscope measurement
		~1500	bagged food, fumiscope measurement
9	sulfuryl fluoride	-	no samples obtained
4	sulfuryl fluoride	~8000	bag from refrigerator, fumiscope measurement
6	methyl bromide	-	no samples obtained
7	methyl bromide	228**	refrigerator bag
		11.5**	tuna fish in refrigerator

\* concentration above upper detection limit of Vikane analyzer. At some sites Fumiscope was not available for measurements or volume of air within commodity not adequate for Fumiscope measurement.

\*\* measurement from syringe sample analyzed by gas chromatography.

FIGURE 1  
CLEARING CREW AVERAGE TWA vs  
FUMIGANT CONCENTRATION PRIOR TO CLEARING



## APPENDIX I

### STUDY PERSONNEL

#### Pest Control Operators of California (PCOC)

-Southern California: Bill Grimm\*  
Chairman, Fumigation Group  
11090 Atlantic Ave  
Lynwood, CA 90262  
(213) 569-8121

John Sansone\*  
Soil Chemicals Corporation  
1152 N. Knollwood Circle  
Anaheim, CA 92801  
(714) 761-3292

-Northern California: Jim Steffenson  
1049 Dell Ave  
Campbell, CA 95008  
(408) 379-5245

#### Los Angeles County Agricultural Commissioner's Personnel

Cato Fiksdal  
Paul Dufourd\*  
Bill Klein\*  
3400 La Madera Ave  
El Monte, CA 91732  
(818) 575-5465

#### Marin County Agricultural Commissioner's Personnel

Jack Schrock  
Marin County Civic Center, Room 422  
San Rafael, CA 94903  
(415) 499-6349

#### Dow Chemical Agricultural Products

Jim Bean  
Route 1, Box 1313  
Davis, CA 95616  
(916) 753-5608

Brian Schneider  
TS&D  
City of Industry  
(818) 810-6762

#### Tri-Cal/Soil Chemicals Corporation

Tom Duafala  
Steve Secara  
Steve Plucker\*  
Amara Ivancovich\*  
P.O. Box 1327  
Hollister, CA 95024  
(408) 637-0195

STUDY PERSONNEL (CONTINUED)

California Department of Food and Agriculture  
Worker Health and Safety Branch Personnel

Dennis Gibbons\*  
Linda O'Connell\*  
John Costello  
Carolyn Rech\*  
1220 N St., A-316  
Sacramento, CA 95814  
(916) 445-8474

\* personnel onsite at some time during study

## APPENDIX II

### PROTOCOL FOR EVALUATION OF STRUCTURE CLEARANCE PROCEDURES

#### PURPOSE

A Two-day study will be conducted to monitor the untarping (aeration) procedures during structural fumigation for methyl bromide and Vikane. The number of structures monitored will be limited to as many fumigations as our cooperators can complete during the two-day period. The primary purpose of this study is to gain data relating to worker exposure to these fumigants during aeration procedures. The secondary purpose is to suggest mitigating measures that could be taken to lessen worker exposure, should particular work practices be found to present unnecessary risks.

#### METHODS AND MATERIALS

The aeration process during a structural fumigation can be broken down into six steps: 1) Breaking the ground seal around the tarps 2) Removing the clips holding the tarps together 3) Opening seams 4) Lifting tarps from behind shrubbery 5) Peeling back the tarps and 6) Folding the tarps. These six tasks all present potential for exposure to these fumigants in varying degrees. These tasks will be monitored separately by taking each worker and monitoring him/her through each separate task. Workers will have personal air pumps attached to their belts in conjunction with three liter Tedlar air sampling bags. Air will be collected by pumping air from a tube positioned in the breathing zone through the pump and into the collection bag. The inlet tube will be positioned on the collar of the worker. As each task is completed, the worker will stop at the sampling station, the bag will be removed and the worker will be provided with a new bag for the next task. Six air bags will be collected from each worker corresponding to each separate task. Air pumps will be calibrated to deliver slightly less than three liters during the period of time of each phase.

As the bags are collected at the sampling station, they will be analyzed with a Xontech portable gas chromatograph for methyl bromide or with an Interscan Vikane Analyzer for Vikane. The Xontech instrument will be calibrated using a methyl bromide permeation tube standard. The Interscan instrument will be calibrated with gas bag standards. Both of the instruments will be calibrated to cover the range of air concentrations expected and the PEL range.

Other considerations relevant to this study will be recorded on the attached data sheet.

## STUDY EQUIPMENT/SUPPLIES

Xontech detector and supplies  
Vikane detector and supplies  
permeation tube calibrator and methyl bromide permeation tube  
nitrogen gas cylinder

10 MSA air pumps  
6 MSA C-210 low volume air pumps  
air pump battery charger  
charging adapters for C-210 pumps

sampling bags, 2 boxes of 3-Liter Tedlar bags  
2-10 liter bags  
gas syringes

Draeger kits, with methyl bromide detector tubes  
Ventilation smoke kit  
temperature/relative humidity meter

tygon tubing, 1 box of 1/4 ID by 3/8 OD to fit inlet on large pumps  
1 box of 3/16 ID by 5/16 OD  
1 box of 1/8 ID by 1/4 OD to fit bag connectors and C-210s

Duct tape  
Safety pins  
scissors  
table, chairs  
Maps or Thomas Guide(s) to LA, Orange county



## APPENDIX III

### REFERENCES

1. Maddy, K.T., J.A. Lowe, D.B. Gibbons, L.P. O'Connell, D.M. Richmond, A.S. Fredrickson: "Studies of Methyl Bromide and Chloropicrin used as Structural Fumigants in California, 1984, I. Evaluation of Chloropicrin as a Warning Agent II. Employee Exposure to Methyl Bromide and Chloropicrin, III. Penetration of Methyl Bromide into Plastic Storage Bags" Report Number HS-1352, Worker Health and Safety Branch, California Department of Food and Agriculture, 1220 N St., Sacramento, CA 95814
2. "Airborne Contaminants," California Code of Regulations, Title 8, Section 5155, 1983, pp. 432.259-432.270.14
3. "Labor," Code of Federal Regulations, Title 29, Part 1910.1000, 1987. pp. 676-682
4. "TLVs<sup>R</sup> - Threshold Limit Values and Biological Exposure Indices for 1987-1988," American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio. 1987. pp. 11-37.
5. Johnson, R.R.: "Elementary Statistics," Boston. PWS Publishers. 1984. pp. 89-93.